

Summary of Flatness Measurements of Blade cooling channels

A batch of 18 CMS Forward Pixel Disk blade-cooling channels was machined to final dimensions as shown in Fig 1.

Flatness measurements of the parts were done with the OGP CMM for all channels. A wide side of the channel is “top” and narrow side is “bottom”. The coordinate system was set on each side of the channel relative to mounting holes as shown in Fig. 1. A $Z = 0$ plane was set measuring three groups of 3 points around the mounting holes. A grid of points on the top and bottom sides of the channel with step of 4 mm along X and 3 mm along Y was used to measure the surface flatness (Fig. 2). At each grid point the X, Y and Z coordinates were recorded. Obtained Z-coordinates are displayed as function of X- coordinate (along the channel) in Fig. 3 for one of the channels. Examples of distributions for surface Z-coordinates in slices in X along Y coordinate and 3-dimensional surface presentation are displayed at Fig. 4 and 5. As measure of non-flatness we take maximum of difference between positive and negative deviations in Z from the $Z = 0$ plane for each channel, $\Delta = Z_{\max} - Z_{\min}$ (Fig.3). The values of the measured non-flatness (warp) are presented in Table and displayed in a histogram in Fig. 6.

All the parts are warped in the middle and three of them more than $\Delta = 100$ microns. It is suggested that parts with non-flatness more than $\Delta = 70$ microns (11 out of 18) should be flattened.

Additional analysis of the accuracy of positions of the mounting holes compared to their nominal positions showed good accuracy of machining which is better than 25 microns as shown by distribution of maximum deviations from nominal position in Fig.7.

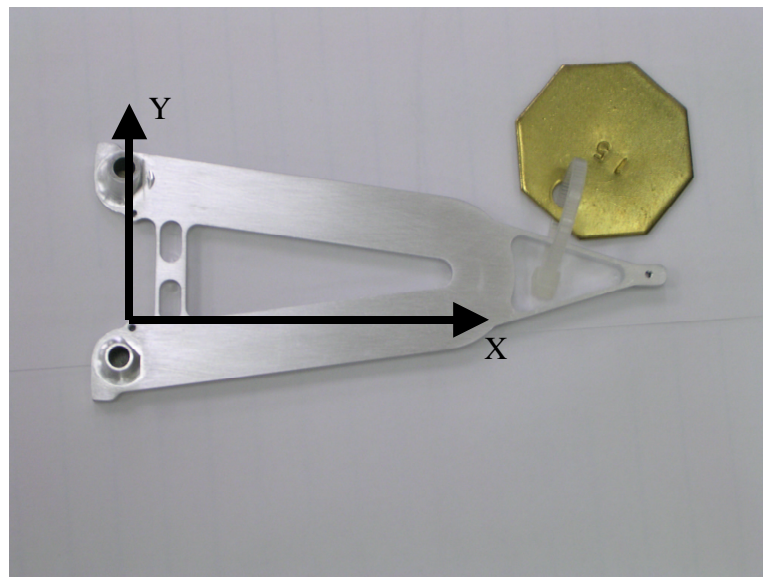


Fig. 1. Photo of one of measured cooling channels

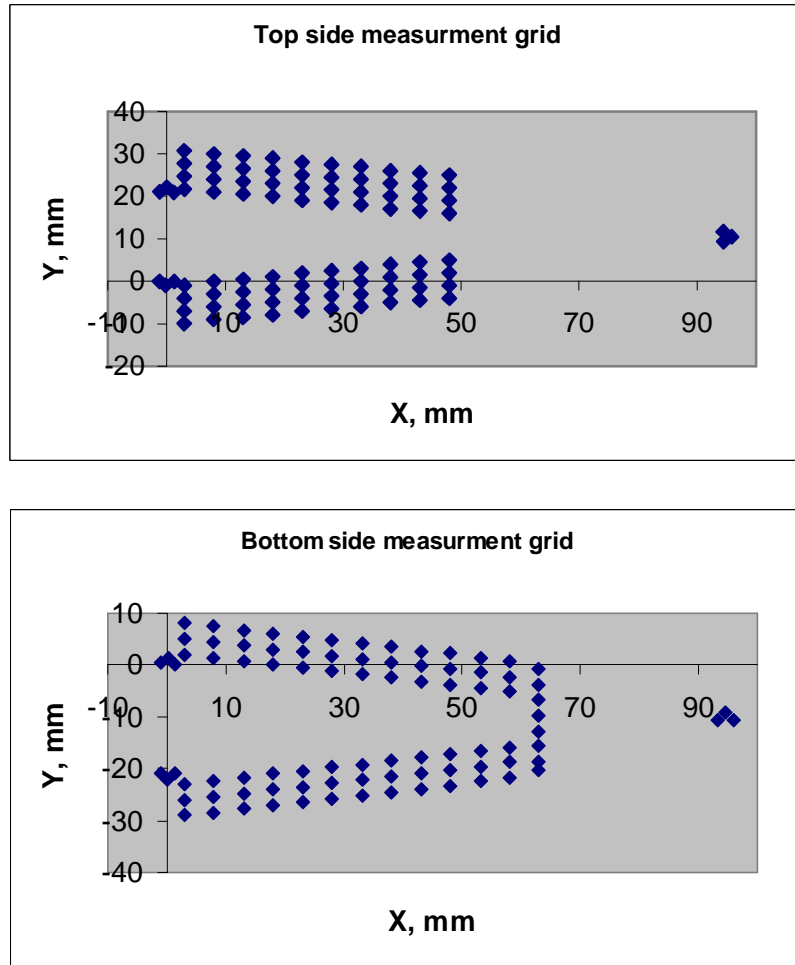


Fig. 2. The flatness measurement grid for two sided of the channel. Also 3 groups of three points around mounting holes defining $Z=0$ plane are displayed.

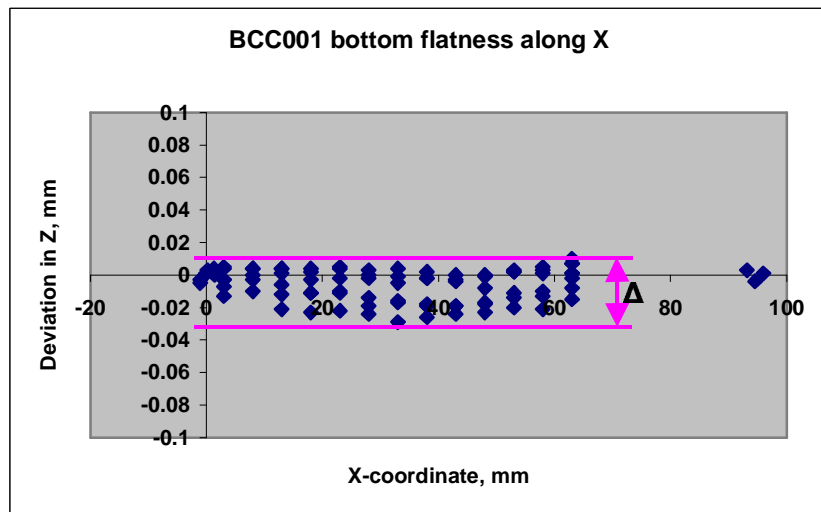


Fig. 3. The flatness of the cooling channel. Value of $\pm \Delta/2$ defines non-flatness of the part.

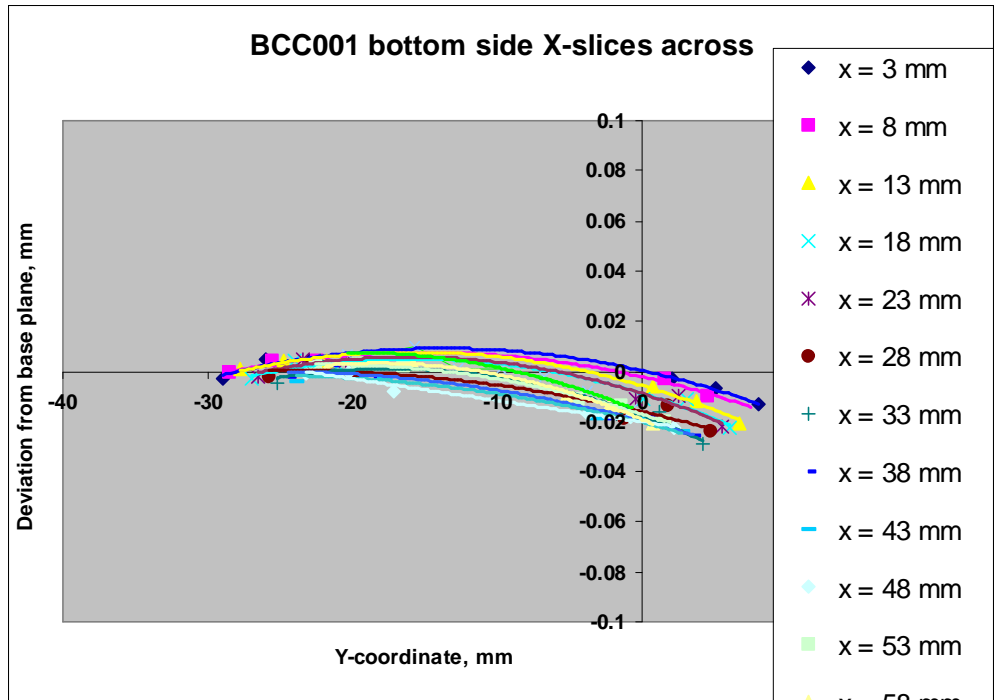


Fig. 4 Non-flatness across the channel (along Y) in slices of X.

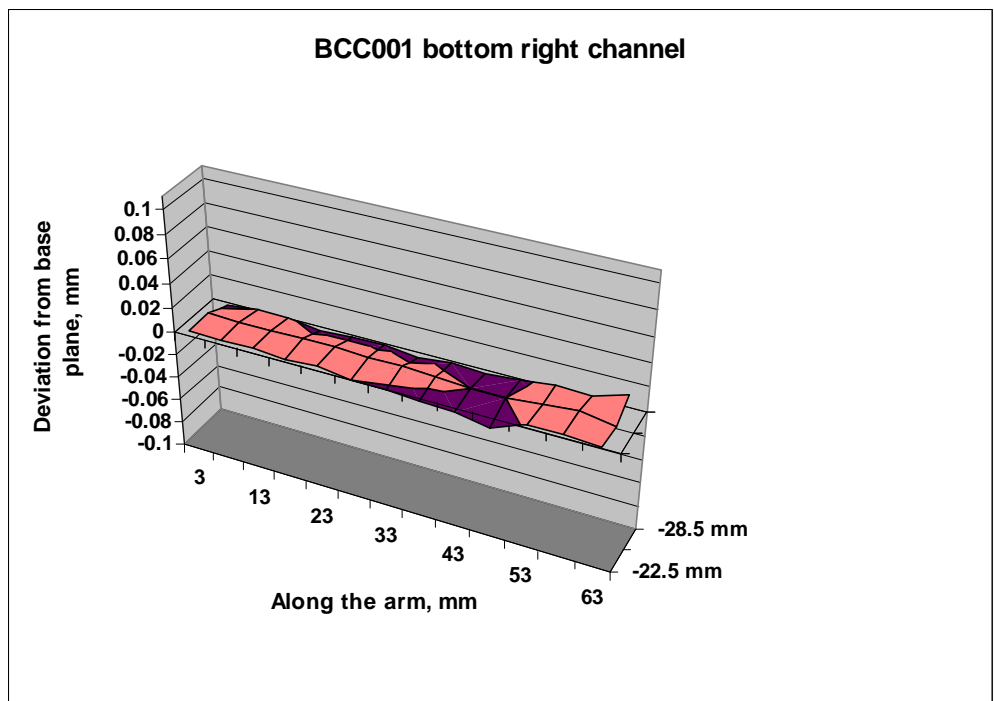


Fig. 4 Surface presentation of channel non-flatness (in X and Y).

Table. Channel non-flatness summary

MK	6/9/2005 Summary of measurements of blade cooling channels # 001 - 018								
	good		O.K.		bad		very bad		
Channel #	1	2	3	4	5	6	7	8	9
Top									
Max	0.052	0.066	0.053	0.012	0.038	0.012	0.007	0.044	0.02
Min	-0.032	-0.035	0	-0.053	-0.05	-0.05	-0.057	-0.059	-0.061
Delta	0.084	0.101	0.053	0.065	0.088	0.062	0.064	0.103	0.081
Average	0.01933	0.022732	0.026821	-0.01563	0.000482	-0.007	-0.02421	-0.00639	-0.01326
StDev	0.021854	0.026503	0.016155	0.014609	0.022082	0.014844	0.013077	0.029253	0.02289
Bot									
Max	0.01	0.006	0.028	0.071	0.031	0.016	0.044	0.042	0.056
Min	-0.029	-0.028	-0.016	0	-0.008	-0.009	-0.007	-0.046	-0.007
Delta	0.039	0.034	0.044	0.071	0.039	0.025	0.051	0.088	0.063
Channel #	10	11	12	13	14	15	16	17	18
Top									
Max	0.039	0.011	0.013	0.02	0.008	0	0	0	0
Min	-0.04	-0.038	-0.04	-0.067	-0.044	-0.098	-0.087	-0.096	-0.102
Delta	0.079	0.049	0.053	0.087	0.052	0.098	0.087	0.096	0.102
Average	0.006134	-0.00828	-0.00363	-0.01604	-0.01041	-0.04705	-0.04506	-0.05553	-0.05347
StDev	0.019693	0.013359	0.012007	0.028207	0.013524	0.026032	0.024639	0.025034	0.028695
Bot									
Max	0.024	0.047	0.037	0.069	0.032	0.061	0.08	0.079	0.098
Min	-0.037	-0.011	-0.009	-0.011	-0.008	-0.012	-0.016	-0.008	-0.002
Delta	0.061	0.058	0.046	0.08	0.04	0.073	0.096	0.087	0.1

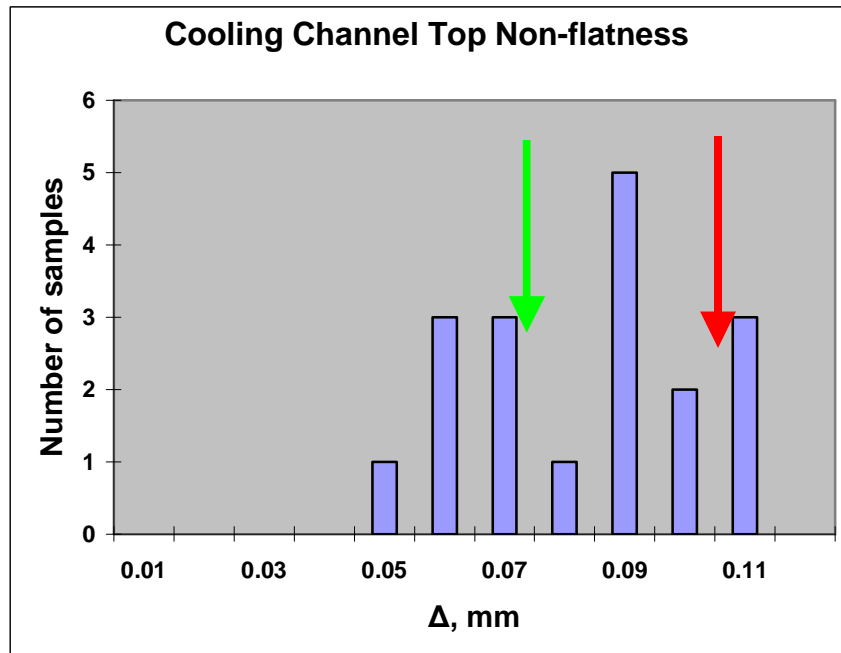


Fig. 6. Distribution of non-flatness of the measured channels. Green arrow shows fully accepted (on the left) channels. Red arrow shows the channels with unacceptable non-flatness (on the right).

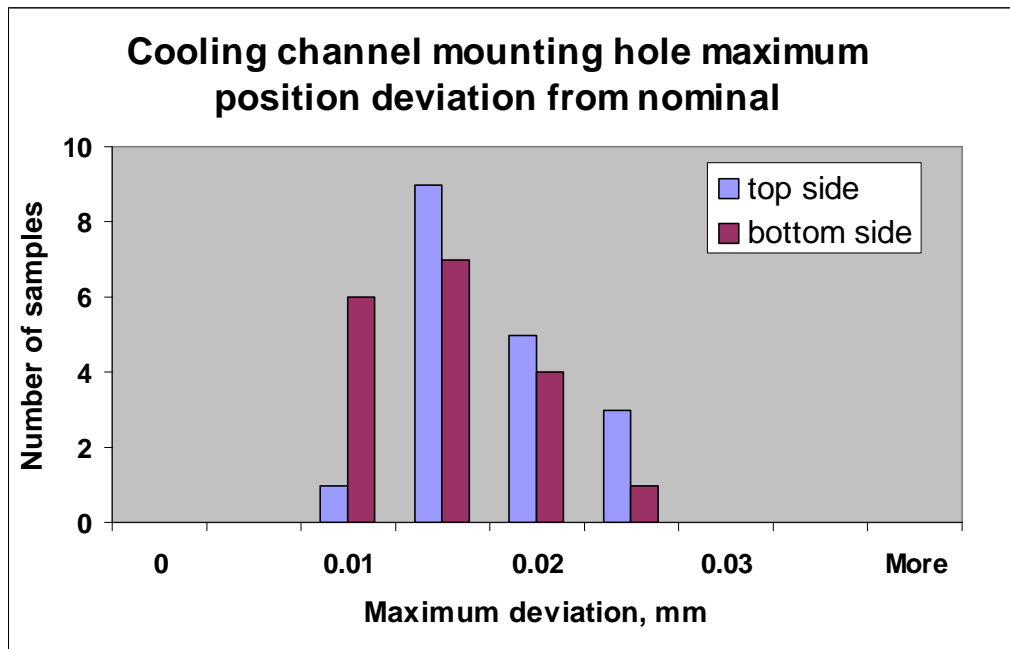


Fig.7. Distribution of maximum deviations of mounting hole positions from nominal